

WHAT WE CLAIM ARE:

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1. A distributed feedback semiconductor laser, comprising:

a lower quantum well structure extending along a resonator direction,  
said lower quantum well structure having a lamination of alternately stacked lower  
5 barrier layer and lower well layer having a band gap narrower than the lower barrier  
layer;

an intermediate layer disposed on said lower quantum well structure,  
said intermediate layer having a band gap broader than the lower well layer and a  
thickness thicker than the lower barrier layer; and

10 an upper quantum well structure periodically disposed on said  
intermediate layer along the resonator direction, said upper quantum well structure  
having a lamination of alternately stacked upper well layer and upper barrier layer  
having a band gap broader than the upper well layer.

15 2. The distributed feedback semiconductor laser according to claim 1, further  
comprising a diffraction-grating-burying layer disposed on said intermediate layer  
along the resonator direction and covering said upper quantum well structure, said  
diffraction-grating-burying layer having a band gap broader than the lower and upper  
well layers.

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3. The distributed feedback semiconductor laser according to claim 2, wherein said  
intermediate layer has a surface step of a same repetition period and a same phase in  
repetition cycle as said upper quantum well structure.

25 4. The distributed feedback semiconductor laser according to claim 2, wherein said  
diffraction-grating-burying layer has a refractive index not higher than a refractive

index of said intermediate layer.

5. The distributed feedback semiconductor laser according to claim 4, wherein said diffraction-grating-burying layer has a refractive index lower than a refractive index of said intermediate layer.

6. The distributed feedback semiconductor laser according to claim 4, wherein the refractive index of said intermediate layer is lower than a refractive index of the lower barrier layer.

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7. The distributed feedback semiconductor laser according to claim 4, wherein the refractive index of said intermediate layer is substantially same as a refractive index of the lower barrier layer.

15 8. The distributed feedback semiconductor laser according to claim 4, wherein the refractive index of said intermediate layer has an intermediate value between a refractive index of the upper and lower barrier layers and a refractive index of said diffraction-grating-burying layer.

20 <sup>16</sup> 9. The distributed feedback semiconductor laser according to claim 1, wherein said intermediate layer has a thickness of not larger than 300 nm under said upper quantum well structure.

10. The distributed feedback semiconductor laser according to claim 4, wherein said intermediate layer and said diffraction-grating-burying layer have a substantially same refractive index.

11. The distributed feedback semiconductor laser according to claim 1, further comprising:

an InP substrate for supporting said lower quantum well structure,

5 wherein the lower and upper well layers are made of InGaAsP having a composition for a 1.5  $\mu\text{m}$  band and the lower and upper barrier layers are made of InGaAsP having a composition for a shorter wavelength than 1.5  $\mu\text{m}$ .

12. The distributed feedback semiconductor laser according to claim 11, wherein the  
10 lower and upper barrier layers are made of InGaAsP having a composition for a 1.2  $\mu\text{m}$  band to 1.4  $\mu\text{m}$  band.

13. The distributed feedback semiconductor laser according to claim 11, wherein said  
intermediate layer is made of InGaAsP having a composition for a 1.2  $\mu\text{m}$  band to a  
15 1.4  $\mu\text{m}$  band.

14. The distributed feedback semiconductor laser according to claim 11, wherein said  
diffraction-grating-burying layer is made of InGaAsP or InP.

20 <sup>9</sup>15. The distributed feedback semiconductor laser according to claim 8, wherein said  
diffraction-grating-burying layer is made of InGaAsP and the distributed feedback  
semiconductor laser further comprises an InP clad layer formed on said diffraction-  
grating-burying layer.

25 <sup>15</sup>16. The distributed feedback semiconductor laser according to claim 11, wherein said  
upper quantum well structure, said intermediate layer and said lower quantum well

structure are shaped in a stripe form and the distributed feedback semiconductor laser is a mesa or ridge type laser.

17. A method of manufacturing a distributed feedback semiconductor laser,

5 comprising the steps of:

(a) growing on a semiconductor substrate a lamination of alternately stacked lower barrier layer and lower well layer having a band gap narrower than the lower barrier layer, to form a lower quantum well structure;

(b) growing an intermediate layer on an uppermost lower well layer, the  
10 intermediate layer having a band gap broader than the lower well layer and a thickness thicker than the lower barrier layer;

(c) growing on the intermediate layer a lamination of alternately stacked upper well layer and upper barrier layer having a band gap broader than the upper well layer and a thickness thinner than the intermediate layer, to form an upper  
15 quantum well structure;

(d) forming a mask on the upper quantum well structure, the mask having periodical pattern;

(e) by using the mask as an etching mask, etching the upper quantum well structure in a periodical shape by using the intermediate layer as an etching  
20 margin layer; and

(f) removing the mask.

18. The method of manufacturing a distributed feedback semiconductor laser according to claim 17, further comprising a step of:

(g) growing a diffraction-grating-burying layer on the intermediate layer  
25 after said step (f), the diffraction-grating-burying layer covering the etched upper

quantum well structure and having a band gap broader than the upper and lower well layers.

19. The method of manufacturing a distributed feedback semiconductor laser  
5 according to claim 18, further comprising a step of:  
(h) growing a clad layer on the diffraction-grating-burying layer after said step (g).

20. The method of manufacturing a distributed feedback semiconductor laser  
10 according to claim 18, further comprising the steps of:  
(i) forming a stripe-shaped hard mask on the diffraction-grating-burying layer, the stripe-shaped hard mask extending along a direction traversing the periodical patterns;  
(j) etching the diffraction-grating-burying layer, the upper quantum well  
15 structure, the intermediate layer and the lower quantum well structure, using the hard mask as an etching mask, to form a mesa structure;  
(k) growing a mesa-burying-layer for burying side walls of the etched mesa structure; and  
(l) removing the hard mask.

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21. The method of manufacturing a distributed feedback semiconductor laser  
according to claim 17, wherein the mask having the periodical patterns is formed by performing two-beam interference exposure and development of a photoresist layer.